

CLAIMS

1. A corrosion-inhibiting conversion coating comprising cobalt, wherein the cobalt is trivalent cobalt, or tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex.
- 5 2. The conversion coating of claim 1 wherein the cobalt/valence stabilizer complex has a solubility in water of between about 5×10^{-1} and about 1×10^{-5} moles per liter of cobalt at about 25°C and about 760 Torr.
- 10 3. The conversion coating of claim 2 wherein the solubility of the cobalt/valence stabilizer complex in water is between about 5×10^{-2} and about 5×10^{-5} moles per liter of cobalt at about 25°C and about 760 Torr.
4. The conversion coating of claim 1 wherein there is an electrostatic barrier layer around the cobalt/valence stabilizer complex in aqueous solution.
5. The conversion coating of claim 1 wherein the cobalt/valence stabilizer complex acts as an ion exchange agent towards corrosive ions.
- 15 6. The conversion coating of claim 1 wherein the conversion coating is between about 25 and about 10,000 nanometers thick.
7. The conversion coating of claim 6 wherein the conversion coating is between about 100 and about 500 nanometers thick.
- 20 8. The conversion coating of claim 1 wherein the conversion coating has a morphology which enhances adhesion of a coating applied over the conversion coating.

9. The conversion coating of claim 1 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

10. The conversion coating of claim 9 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates, tungstates, vanadates, niobates, tantalates, tellurates, periodates, iodates, carbonates, antimonates, stannates, titanates, zirconates, hafnates, bismuthates, germanates, arsenates, phosphates, borates, aluminates, and silicates, and combinations thereof.

11. The conversion coating of claim 10 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates, tungstates, vanadates, niobates, tantalates, tellurates, periodates, iodates, carbonates, antimonates, and stannates, and combinations thereof.

12. The conversion coating of claim 10 wherein the cobalt/valence stabilizer complex has a central cavity containing a cobalt ion and an additional ion.

13. The conversion coating of claim 12 wherein the additional ion is B^{+3} , Al^{+3} , Si^{+4} , P^{+5} , Ti^{+4} , V^{+5} , V^{+4} , Cr^{+6} , Cr^{+3} , Mn^{+4} , Mn^{+3} , Mn^{+2} , Fe^{+3} , Fe^{+2} , Co^{+2} , Ni^{+2} , Ni^{+3} , Ni^{+4} , Cu^{+2} , Cu^{+3} , Zn^{+2} , Ga^{+3} , Ge^{+4} , As^{+5} , As^{+3} , Zr^{+4} , or Ce^{+4} .

14. The conversion coating of claim 9 wherein the valence stabilizer is the organic valence stabilizer selected from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-membered heterocyclic rings containing one to four nitrogen atoms optionally having additional nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing one or two sulfur atoms and having additional nitrogen binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-

sulfur, or nitrogen-oxygen macrocyclics; macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or imido- derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases containing at least two azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases with ortho- (for aryl) or alpha- or beta- (for alkyl) substitution; oximes; amidines and imido compounds; dithio ligands; amides; amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho-aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silylaminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanyls; guanidinoureas; 2-nitrosophenols; 2-nitrophenols; N-nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacylacetamides; 2-acylthioacetamides; dithiodicarbonyl diamides; trithiodicarboxylic acids and salts; monothiocarbamates; monothioethers; dithioethers; trithioethers; tetrathioethers; pentathioethers; hexathioethers; disulfides; monophosphines; diphosphines; triphosphines; tetraphosphines; pentaphosphines; hexaphosphines; five- or six-membered heterocyclic rings containing one or two sulfur atoms optionally having additional sulfur, oxygen, or phosphorus binding sites; five- or six-membered heterocyclic rings containing one to three phosphorus atoms optionally having additional phosphorus, nitrogen, oxygen, or sulfur binding sites; five- or six-membered heterocyclic rings containing one to four nitrogen atoms and having additional phosphorus binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional sulfur or phosphorus binding sites; (five-, seven-, or nine-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; (two- to ten-)membered sulfur, sulfur-oxygen, or sulfur-phosphorus macrocyclics, not including oligothioketones or dithiolenes; (two- to ten-)membered phosphorus, nitrogen-phosphorus, or oxygen-phosphorus macrocyclics; thio-, amido-, or imido- derivatives of phosphonic and diphosphonic acids and salts containing no sulfur binding sites; amido-, or imido- derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts containing no sulfur binding sites; dithioperoxydiphosphoramides; dithioperoxydiphosphoric acids and salts; monothioperoxydiphosphoramides;

monothioperoxydiphosphoric acids and salts; monothiophosphoric acids;
phosphoro(dithioperoxoic) acids and salts; azo compounds, triazenes, formazans, azines, or
Schiff Bases; silylamines; silazanes; guanidines and diguanidines; pyridinaldimines;
hydrazones; hydramides; nitriles; thioureas and thioamides; ureas and biurets; monothio
5 ligands; diketone ligands; dithioacyl disulfides; tetrathioperoxydicarbonic diamides; (hexa-,
penta-, or tetra-)thioperoxydicarbonic acids and salts; 1,2-dithiolates; rhodanines;
dithiocarbimates; (thio)xanthates; S-(alkyl- or aryl-thio)thiocarboxylic acids and salts;
phosphinodithioformates; (thio)borates and (thio)boronates; (thio)arsonic acids and salts;
(thio)antimonic acids and salts; phosphine and arsine sulfides or oxides; beta-hydroxyketones
10 and -aldehydes; squaric acids and salts; carbonates; carbamates and carbimates; carbazates;
imidodisulfurous diamides; sulfur diimines; thiocarbonyl and mercapto oximes; 2-
nitrothiophenols; 2-nitrilo(thio)phenols; acylcyanamides; imidates; 2-amidinoacetates; beta-
ketoamines; 3-aminoacrylamides and 3,3-diaminoacrylamides; 3-aminoacrylic acids and salts
and 3-hydroxy-3-aminoacrylic acids and salts; 2-nitroanilines; amine and diazine N-oxides;
15 hydrazides and semicarbazides; (amino- or imino-)aryl phosphines; (thio- or hydroxy-)aryl
phosphines; arsines; five- or six-membered heterocyclic rings containing one arsenic atom
optionally having additional arsenic binding sites; (two- to six-)membered arsenic macrocyclics;
selenoethers; five- or six-membered heterocyclic rings containing one or two selenium atoms
optionally having additional selenium binding sites; (two- to six-)membered selenium
20 macrocyclics; 1,3-diselenoketones; 1,1-diselenolates; diselenocarbamates; selenophosphoric
acids and salts; selenocarbonates; cyanide, isocyanide, and cyanamide ligands; nitrosyl and
nitrite ligands; azide ligands; thiolates and selenolates; (thio)cyanate ligands; diene or bicyclic
or tricyclic hydrocarbon ligands; and carbonyl, halogen, or hydroxo ligands; and combinations
thereof.

15. The conversion coating of claim 14 wherein the organic valence stabilizer is selected
from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-
membered heterocyclic rings containing one to four nitrogen atoms optionally having additional

nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing one or two sulfur atoms and having additional nitrogen binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or imido- derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases containing at least two azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases with ortho- (for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases; oximes; amidines and imido compounds; dithio ligands; amides; amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho-aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silylaminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanylureas; guanidinoureas; 2-nitrosophenols; 2-nitrophenols; N-nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacylacetamides; 2-acylthioacetamides; dithiodicarbonyl diamides; trithiodicarboxylic acids and salts; and monothiocarbamates; and combinations thereof.

16. The conversion coating of claim 14 wherein the organic valence stabilizer is the diazene selected from diazeneformimidamides; diazeneformamides; diazeneformothioamides; diazeneacetimidamides; diazeneacetothioamides; diazeneformimidic acids and salts; diazeneacetimidic acids and salts; diazenecarbothioic acids and salts; diazenecarbodithioic acids and salts; diazeneformimidothioic acids and salts; diazeneformaldehydes; diazeneformothioaldehydes; diazeneacetaldehydes; diazeneacetothioaldehydes; diazenediformamides; diazenediformothioamides; diazenediacetamides; diazenediacetothioamides; diazeneacetimidothioic acids and salts; imidoaldiazenes; diazenediformimidamides; diazenediacetimidamides; diazenediformimidic acids and salts; diazenediacetimidic acids and salts; diazenediformimidothioic acids and salts;

diazenediacetimidothioic acids and salts; diazenedicarbothioic acids; diazenedicarbodithioic acids; diazeneformic acids; diazenediformic acids; diazeneacetic acids; diazenediacetic acids; diazenediformaldehydes; diazenediformothioaldehydes; diazenediacetaldehydes; diazenediacetothioaldehydes; and diimidoyldiazenes; and combinations thereof.

- 5 17. The conversion coating of claim 14 wherein the organic valence stabilizer is the thio-, amido-, or imido- derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts selected from phosphoramidimidic triamides; phosphoramidimidic acids and salts; phosphorodiamidimidic acids and salts; phosphorodiamidimidothioic acids and salts; phosphoramidimidothioic acids and salts; phosphorodiamidimidodithioic acids and salts; phosphoramidimidodithioic acids and salts; (di- or mono-)thiohypophosphoric acids and salts; (di- or mono-)thiohypophosphoramides; phosphoramidic acids and salts; phosphorimidic acids and salts; (di- or mono-)thioimidodiphosphoric acids and salts; (di- or mono-)thiohydrazidodiphosphoric acids and salts; (di- or mono-)thioimidodiphosphoramides; (di- or mono-)thiohydrazidodiphosphoramides; phosphoric triamides; (di- or mono-)thiodiphosphoramides; (di- or mono-)thiodiphosphoric acids and salts; (tetra-, tri-, di-)thiophosphoric acids and salts; phosphoro(dithioperoxo)(mono-, di-, or tri-)thioic acids and salts; phosphorimido(mono-, di-, or tri-)thioic acids and salts; phosphorothioic triamides; phosphoramido(mono, di- or tri-)thioic acids and salts; and phosphorodiamido(mono, di- or tri-)thioic acids and salts; and combinations thereof.
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- 20 18. The conversion coating of claim 14 wherein the organic valence stabilizer is a substituent for the ortho- (for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases selected from amino; imino; oximo; diazeno; hydrazido; thiol; mercapto; thiocarbonyl; hydroxy; carbox; and carbonyl substituents; and combinations thereof.

19. The conversion coating of claim 14 wherein the organic valence stabilizer is the oxime selected from monooximes; dioximes; carbonyl oximes; imine oximes; hydroxy oximes; amino oximes; amido oximes; hydrazone oximes; and azo oximes; and combinations thereof.

20. The conversion coating of claim 14 wherein the organic valence stabilizer is the amidine and imido compound selected from amidines; diamidines; biguanides; biguanidines; diamidinomethanes; imidoylguanidines; amidinoguanidines; diformamidine oxides, sulfides, and disulfides; imidodicarbonimidic acids and salts; diimidodicarbonimidic acids and salts; thioimidodicarbonimidic acids and salts; thiodiimidodicarbonimidic acids and salts; diimidoylimines; diimidoylhydrazides; imidosulfamides; diimidosulfamides; O-amidinocarbamates; O- or S-amidino(mono-, di-, or peroxy-)thiocarbamates; N-hydroxy(or N,N'-dihydroxy)amidines; and diimidosulfuric acids and salts; and combinations thereof.

21. The conversion coating of claim 14 wherein the organic valence stabilizer is the dithio ligand selected from dithioimidodialdehydes; dithiohydrazidodialdehydes; dithioimidodicarbonic acids and salts; dithiohydrazidodicarbonic acids and salts; 1,3-dithioketones; 1,2-dithioketones; dithiomalonamides; 2-thioacylthioacetamides; dithioacyl sulfides; trithiodicarbonic diamides; (penta-, tetra-, tri-)thiodicarbonic acids and salts; beta-mercaptothioketones and -aldehydes; N-(aminomethylthiol)thioureas; dithiooxamides; 1,1-dithiolates; (di- or per-)thiomonocarboxylic acids and salts; (tetra- or per-)thiodicarboxylic acids and salts; (di-, tri-, or per-)thiocarbonates; dithiocarbamates (including N-hydroxydithiocarbamates and N-mercaptodithiocarbamates); and dithiocarbazates; and combinations thereof.

22. The conversion coating of claim 14 wherein the organic valence stabilizer is the amide selected from monoamides; lactams; amidinoamides; guanidinoamides; imidoylamides; polyamides; and polylactams; and combinations thereof.

23. The conversion coating of claim 14 wherein the organic valence stabilizer is the thio-, amido-, or imido- derivative of phosphonic and diphosphonic acids and salts selected from phosphonitrile amides; phosphonimidic diamides; phosphonamidimidic acids and salts; phosphonamidimidothioic acids and salts; dithioimidodiphosphonic acids and salts; dithiohydrazidodiphosphonic acids and salts; dithioimidodiphosphonamides; dithiohydrazidodiphosphonamides; dithiodiphosphonamides; dithiodiphosphonic acids and salts; dithioperoxydiphosphonamides; dithioperoxydiphosphonic acids and salts; (di- and tri-)thiophosphonic acids and salts; phosphono(dithioperoxo)thioic acids and salts; phosphono(dithioperoxo)dithioic acids and salts; phosphonimidothioic acids and salts; phosphonimidodithioic acids and salts; phosphonothioic acids and salts; phosphonanidothioic acids and salts; phosphonamidimidodithioic acids and salts; monothioimidodiphosphonic acids and salts; monothiohydrazidodiphosphonic acids and salts; monothioimidodiphosphonamides; monothiohydrazidodiphosphonamides; monothiodiphosphonamides; monothiodiphosphonic acids and salts; monothioperoxydiphosphonamides; monothioperoxydiphosphonic acids and salts; monothiophosphonic acids and salts; and phosphono(dithioperoxoic) acids and salts; and combinations thereof.

24. The conversion coating of claim 14 wherein the organic valence stabilizer is the amido-, or imido- derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts containing no sulfur binding sites selected from hypophosphoric acids and salts; hypophosphoramides; imidodiphosphoric acids and salts; hydrazidodiphosphoric acids and salts; imidodiphosphoramides; hydrazidodiphosphoramides; and diphosphoramides; and combinations thereof.

25. The conversion coating of claim 14 wherein the organic valence stabilizer is the amido-, or imido- derivative of phosphonic or diphosphonic acids and salts containing no sulfur binding sites selected from imidodiphosphonic acids and salts; hydrazidodiphosphonic acids and salts; imidodiphosphonamides; hydrazidodiphosphonamides; diphosphonamides; phosphonimidic

acids and salts; phosphonamidic acids and salts; and phosphonic diamides; and combinations thereof.

26. The conversion coating of claim 14 wherein the organic valence stabilizer is the thiourea and thioamide selected from thioureas; thiocarboxamides; thioacylthioureas, acylthioureas, and thioacylureas; thioaroylthioureas, aroylthioureas, and thioaroylureas; thioimidates; thioguanylylureas; guanidinothioureas; amidinothioamides; guanidinothioamides; imidothioamides; 3-aminothioacrylamides; thiohydrazides; thiosemicarbazides; (mono- and di-)thiobiurets; (mono- and di-)thioisobiurets; (mono- and di-)thiobiureas; N-(aminomethylol)thioureas; N-(aminomethylthiol)ureas; and beta-mercaptocarboxamides; and combinations thereof.

27. The conversion coating of claim 14 wherein the organic valence stabilizer is the urea and biuret selected from ureas; pseudoureas; biurets; isobiurets; biureas; acylureas; aroylureas; and N-(aminomethylol)ureas; and combinations thereof.

28. The conversion coating of claim 14 wherein the organic valence stabilizer is the monothio ligand selected from beta-aminothiones; 3-aminothioacrylic acids and salts; 3-mercapto-3-aminothioacrylic acids and salts; N-thioacyl benzylidenimines; thioimidodialdehydes; thiohydrazidodialdehydes; thioimidodicarbonic acids and salts; thiohydrazidodicarbonic acids and salts; 1,2-monothioketones; trithioperoxydicarbonic diamides; dithioperoxydicarbonic diamides; dithiodicarbonic acids and salts; trithioperoxydicarbonic acids and salts; beta-hydroxythioketones; beta-hydroxythioaldehydes; beta-mercaptoketones; beta-mercaptoaldehydes; monothiooxamides; beta-mercaptocarboxylic acids and salts; beta-mercaptothiocarboxylic acids and salts; beta-hydroxythiocarboxylic acids and salts; S-alkylthiocarboxylic acids and salts; S-arylthiocarboxylic acids and salts; S-alkyldisulfidocarboxylic acids and salts; S-aryldisulfidocarboxylic acids and salts; monothiomonocarboxylic acids and salts; dithiodicarboxylic acids and salts;

monothiocarbonates; monothiocarbazates; monothiocarbimides; mercaptoalcohols; and silylmercaptoalcohols; and combinations thereof.

29. The conversion coating of claim 14 wherein the organic valence stabilizer is the diketone ligand selected from imidodialdehydes; hydrazidodialdehydes; imidodicarbonic acids and salts; hydrazidodicarbonic acids and salts; imidodisulfamic acids and salts; imidodisulfuric acids and salts; 1,3-diketones; 1,2-diketones; malonamides; 2-acylacetamides; monothiodicarbonic diamides; monothiodicarbonic acids and salts; dithioperoxydicarbonic acids and salts; trithionic acids and salts; oxamides; and dicarboxylic acids; and combinations thereof.

30. The conversion coating of claim 14 wherein the organic valence stabilizer is the S-(alkyl- or aryl-thio)thiocarboxylic acid and salt selected from S-(alkylthio)thiocarboxylic acids and salts; S-(arythio)thiocarboxylic acids and salts; S,S-thiobisthiocarboxylic acids and salts; S-(alkyldisulfido)thiocarboxylic acids and salts; S-(aryldisulfido)thiocarboxylic acids and salts; and S,S'-disulfidobisthiocarboxylic acids and salts; and combinations thereof.

31. The conversion coating of claim 14 wherein the organic valence stabilizer is the phosphine and arsine sulfide or oxide selected from phosphine P-sulfides; aminophosphine sulfides; arsine As-sulfides; aminoarsine sulfides; phosphine P-oxides; aminophosphine oxides; arsine As-oxides; and aminoarsine oxides; and combinations thereof.

32. The conversion coating of claim 14 wherein the solubility in water of the cobalt/valence stabilizer complex is adjusted by the addition of a substituent group on the organic valence stabilizer.

33. The conversion coating of claim 32 wherein the solubility in water is increased by the addition of the substituent group selected from sulfonate groups ($-\text{SO}_3^-$), carboxyl groups ($-\text{CO}_2^-$),

), hydroxyl groups (-OH), ester groups (-CO₃-), carbonyl groups (=C=O), amine groups (-NH₂), nitrosamine groups (=N-N=O), carbonylnitrene groups (-CO-N), sulfoxide groups (=S=O), sulfone groups (=S[=O]₂), sulfinyl groups (-N=S=O), sulfodiimines (=S[=NH]₂), sulfonyl halide groups (-S[=O]₂X), sulfonamide groups (-S[=O]₂NH₂), monohalosulfonamide groups (-S[=O]₂NHX), dihalosulfonamide groups (-S[=O]₂MX₂), halosulfonate groups (-S[=O]₂OX), halosulfonate amide groups (=N-S[=O]₂X), aminosulfonate groups (=N-S[=O]₂OH), iminosulfonate groups (-N[SO₃⁻]₁₋₂), phosphonate groups (-PO₃⁻²), phosphonamide groups (-PO₂NH₂⁻), phosphondiamide groups (-PO[NH₂]₂), aminophosphonate groups (=N-PO₃⁻²), and iminophosphonate groups (-N[PO₃⁻²]₁₋₂), and combinations thereof.

34. The conversion coating of claim 32 wherein the solubility in water is decreased by the addition of the substituent group selected from nitro groups (-NO₂), perfluoroalkyl groups (-C_xF_{2x+1}), perchloroalkyl groups (-C_xCl_{2x+1}), nitramine groups (=N-NO₂), thioketone groups (=C=S), sulfenyl halide groups (-S-X), and sulfur dihaloimide groups (-N=SX₂), and combinations thereof.

35. The conversion coating of claim 14 wherein an electrostatic barrier layer of the cobalt/valence stabilizer complex is adjusted by the addition of a substituent group on the organic valence stabilizer.

36. The conversion coating of claim 35 wherein the electrostatic barrier layer is increased by the addition of the substituent group selected from ketones (=C=O), thioketones (=C=S), amides (-C[=O]-NR₂), thioamides (-C[=S]-NR₂), nitriles or cyano groups, (-CN), isocyanides (-NC), nitroso groups (-N=O), thionitroso groups (-N=S), nitro groups (-NO₂), azido groups (-N₃), cyanamide or cyanonitrene groups (=N-CN), cyanate groups (-O-CN), isocyanate groups (-N=C=O), thiocyanate groups (-S-CN), isothiocyanate groups (-N=C=S), nitrosamine groups (=N-N=O), thionitrosamine groups (=N-N=S), nitramine groups (=N-NO₂), thionitramine groups (=N-NS₂), carbonylnitrene groups (-CO-N), thiocarbonylnitrene groups (-CS-N),

sulfenyl halides (-S-X), sulfoxides (=S=O), sulfones (=S[=O]₂), sulfinyl groups (-N=S=O), thiosulfinyl groups (-N=S=S), sulfenyl thiocyanato groups (-S-S-CN), sulfenyl cyanato groups (-S-O-CN), sulfodiimine groups (=S[=NH]₂), sulfur dihaloimido groups (-N=SX₂), sulfur oxide dihaloimido groups (-N=S[=O]X₂), aminosulfur oxide trihalide groups (=N-S[=O]X₃), sulfonyl azide groups (-S[=O]₂N₃), sulfonyl thiocyanate groups (-S[=O]₂SCN), sulfonyl cyanate groups (-S[=O]₂OCN), sulfonyl cyanide groups (-S[=O]₂CN), halosulfonate groups (-S[=O]₂OX), phosphonyl thiocyanate groups (-P[=O]OHSCN), phosphonyl cyanate groups (-P[=O]OHOCN), and phosphonyl cyanide groups (-P[=O]OHCN), and combinations thereof.

37. The conversion coating of claim 1 further comprising a solubility control agent.

38. The conversion coating of claim 37 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

39. The conversion coating of claim 38 wherein the solubility control agent is the cationic solubility control agent selected from H⁺, Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺, NH₄⁺, Mg⁺², Ca⁺², Sr⁺², Be⁺², Ba⁺², Y⁺³, La⁺³, Ce⁺³, Ce⁺⁴, Nd⁺³, Pr⁺³, Sc⁺³, Sm⁺³, Eu⁺³, Eu⁺², Gd⁺³, Tb⁺³, Dy⁺³, Ho⁺³, Er⁺³, Tm⁺³, Yb⁺³, Lu⁺³, Ti⁺⁴, Zr⁺⁴, Ti⁺³, Hf⁺⁴, Nb⁺⁵, Ta⁺⁵, Nb⁺⁴, Ta⁺⁴, V⁺⁵, V⁺⁴, V⁺³, Mo⁺⁶, W⁺⁶, Mo⁺⁵, W⁺⁵, Mo⁺⁴, W⁺⁴, Cr⁺³, Mn⁺², Mn⁺³, Mn⁺⁴, Fe⁺², Fe⁺³, Co⁺², Co⁺³, Ni⁺², Ni⁺³, Ni⁺⁴, Ru⁺², Ru⁺³, Ru⁺⁴, Rh⁺³, Ir⁺³, Rh⁺², Ir⁺², Pd⁺⁴, Pt⁺⁴, Pd⁺², Pt⁺², Os⁺⁴, Cu⁺, Cu⁺², Cu⁺³, Ag⁺, Ag⁺², Ag⁺³, Au⁺, Au⁺², Au⁺³, Zn⁺², Cd⁺², Hg⁺, Hg⁺², Al⁺³, Ga⁺³, Ga⁺, In⁺³, In⁺, Tl⁺³, Tl⁺, Ge⁺⁴, Ge⁺², Sn⁺⁴, Sn⁺², Pb⁺⁴, Pb⁺², Sb⁺³, Sb⁺⁵, As⁺³, As⁺⁵, Bi⁺³, Bi⁺⁵, organic compounds containing at least one N⁺ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one arsonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one selenonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR₄⁺, where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

40. The conversion coating of claim 39 wherein the cationic solubility control agent is selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ru^{+2} , Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Sb^{+3} , Sb^{+5} , Bi^{+3} , Bi^{+5} , organic compounds containing at least one N^+ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR_4^+ , where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

41. The conversion coating of claim 38 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates;

nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates;
tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates;
tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates;
tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides;
5 tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates;
triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates;
(thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides;
di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates;
triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates;
10 di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates;
cyanonickelates; cyanatochromates; cyanatonicelates; thiocyanatochromates;
thiocyanatonicelates; cyanamidochromates; cyanamidonicelates; nitritonicelates; arsonates;
diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites;
fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates;
15 iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronicelates;
chromates; Reinecke's salt; and vanadates; and combinations thereof.

42. The conversion coating of claim 41 wherein the anionic solubility control agent is
selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates;
fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates;
20 permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates;
fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates;
fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates;
nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites;
thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates;
25 fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites;
dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides;
bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides;

5 cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates;
cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates;
thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides;
cyanamidoferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates;
10 nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates;
tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates;
tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates;
tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides;
tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates;
15 triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates;
(thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides;
di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates;
triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates;
di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

15 43. The conversion coating of claim 1 wherein the conversion coating is colored.

44. The conversion coating of claim 43 further comprising an agent which improves color-fastness of the conversion coating.

45. The conversion coating of claim 44 wherein the agent which improves color-fastness is selected from an active UV blocker, a passive UV blocker, and a brightener.

20 46. The conversion coating of claim 45 wherein the agent which improves color-fastness is the active UV blocker selected from carbon black, graphite, and phthalocyanines.

47. The conversion coating of claim 45 wherein the agent which improves color-fastness is the passive UV blocker selected from titanium oxide, tin oxide, lead oxide, silicon oxide,

silicates, and aluminosilicates, and combinations thereof.

48. The conversion coating of claim 45 wherein the agent which improves color-fastness is the brightener selected from sulfonic acids, sulfonates, sulfonamides, sulfonimides, sulfinic acids, sulfones, cyanides, and nonionic surfactants.

5 49. A method of making a corrosion-inhibiting conversion coating bath comprising:
providing a solvent;
providing a cobalt source;
providing a valence stabilizer; and
combining the cobalt source and the valence stabilizer to form a cobalt/valence
10 stabilizer complex.

50. The method of claim 49 wherein the solvent comprises water.

51. The method of claim 49 wherein the cobalt source is selected from divalent cobalt sources, trivalent cobalt sources, and tetravalent cobalt sources, and combinations thereof.

52. The method of claim 51 wherein the cobalt source is the divalent cobalt source.

15 53. The method of claim 49 further comprising oxidizing the cobalt source.

54. The method of claim 53 wherein the cobalt source is oxidized by adding an oxidizer to the conversion coating bath.

55. The method of claim 53 wherein the cobalt source is oxidized by electrolysis.

56. The method of claim 54 wherein the oxidizer is selected from a dissolved solid, a liquid, and a gas.

57. The method of claim 54 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrates, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vandates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, and dissolved fluorine, and combinations thereof.

58. The method of claim 49 wherein the cobalt source is cobalt nitrate, cobalt sulfate, cobalt perchlorate, cobalt chloride, cobalt fluoride, cobalt bromide, cobalt iodide, cobalt bromate, cobalt chlorate, cobalt fluosilicate, cobalt fluotitanate, cobalt fluozirconate, cobalt fluoborate, cobalt fluoaluminate, cobalt formate, cobalt acetate, cobalt propionate, cobalt butyrate, cobalt benzoate, cobalt glycolate, cobalt lactate, cobalt tartronate, cobalt malate, cobalt tartrate, cobalt citrate, cobalt benzenesulfonate, cobalt thiocyanate, cobalt acetylacetonate, ammonium cobalt sulfate, ammonium cobalt nitrate, ammonium cobalt chloride, ammonium cobalt bromide, hexaamminecobalt chloride, hexaamminecobalt bromide, hexaamminecobalt nitrate, pentaamminecobalt chloride, pentaamminecobalt bromide, pentaamminecobalt nitrate, lithium cobaltinitrite, sodium cobaltinitrite, tris(ethylenediamine)cobalt chloride, tris(ethylenediamine)cobalt nitrate, bipyridine complexes of trivalent cobalt, phenanthroline complexes of trivalent cobalt, or cobaltcarbonates, or combinations thereof.

59. The method of claim 49 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

60. The method of claim 49 further comprising adding an optional preparative agent to the conversion coating bath.

61. The method of claim 60 wherein the preparative agent is selected from fluorides, chlorides, bromides, acidic species, and hydroxides, and combinations thereof.

62. The method of claim 61 wherein the preparative agent is a fluoride.

63. The method of claim 62 wherein the fluoride is selected from fluorozirconates, fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates, fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates, fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates, fluoroargentates, fluorozincates, fluorohafnates, fluorovanadates, fluoroniobates, fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates, fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates, fluorocobaltates, potassium fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride, hydrofluoric acid, dissolved fluorine, and organic fluorides, and combinations thereof.

64. The method of claim 49 further comprising providing a solubility control agent.

65. The method of claim 64 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

66. The method of claim 65 wherein the solubility control agent is the cationic solubility control agent selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Be^{+2} , Ba^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , V^{+5} , V^{+4} , V^{+3} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Cr^{+3} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ni^{+2} , Ni^{+3} , Ni^{+4} , Ru^{+2} , Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Os^{+4} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Cd^{+2} , Hg^+ , Hg^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Tl^{+3} , Tl^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Pb^{+4} , Pb^{+2} , Sb^{+3} , Sb^{+5} ,

As⁺³, As⁺⁵, Bi⁺³, Bi⁺⁵, organic compounds containing at least one N⁺ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one arsonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one selenonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR₄⁺, where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

67. The method of claim 66 wherein the cationic solubility control agent is selected from H⁺, Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺, NH₄⁺, Mg⁺², Ca⁺², Sr⁺², Y⁺³, La⁺³, Ce⁺³, Ce⁺⁴, Nd⁺³, Pr⁺³, Sc⁺³, Sm⁺³, Eu⁺³, Eu⁺², Gd⁺³, Tb⁺³, Dy⁺³, Ho⁺³, Er⁺³, Tm⁺³, Yb⁺³, Lu⁺³, Ti⁺⁴, Zr⁺⁴, Ti⁺³, Hf⁺⁴, Nb⁺⁵, Ta⁺⁵, Nb⁺⁴, Ta⁺⁴, Mo⁺⁶, W⁺⁶, Mo⁺⁵, W⁺⁵, Mo⁺⁴, W⁺⁴, Mn⁺², Mn⁺³, Mn⁺⁴, Fe⁺², Fe⁺³, Co⁺², Co⁺³, Ru⁺², Ru⁺³, Ru⁺⁴, Rh⁺³, Ir⁺³, Rh⁺², Ir⁺², Pd⁺⁴, Pt⁺⁴, Pd⁺², Pt⁺², Cu⁺, Cu⁺², Cu⁺³, Ag⁺, Ag⁺², Ag⁺³, Au⁺, Au⁺², Au⁺³, Zn⁺², Al⁺³, Ga⁺³, Ga⁺, In⁺³, In⁺, Ge⁺⁴, Ge⁺², Sn⁺⁴, Sn⁺², Sb⁺³, Sb⁺⁵, Bi⁺³, Bi⁺⁵, organic compounds containing at least one N⁺ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR₄⁺, where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

68. The method of claim 65 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites;

thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates;
fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites;
dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides;
bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides;
5 cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates;
cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates;
thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides;
cyanamidoferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates;
nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates;
10 tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates;
tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates;
tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides;
tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates;
triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates;
15 (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides;
di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates;
triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates;
di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates;
cyanonickelates; cyanatochromates; cyanatonickeles; thiocyanatochromates;
20 thiocyanatonickeles; cyanamidochromates; cyanamidonickeles; nitritonickeles; arsonates;
diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites;
fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates;
iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronickeles;
chromates; Reinecke's salt; and vanadates; and combinations thereof.

25 69. The method of claim 68 wherein the anionic solubility control agent is selected from
fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates;
chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates;

fluoromanganates; chloromanganates; fluoroferates; chloroferates; fluorocobaltates;
chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates;
chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides;
cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates;
5 thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates;
chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates;
fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates;
iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates;
cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates;
10 cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates;
thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferrates;
cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferrates;
nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates;
tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates;
15 tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates;
(thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides;
amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates;
imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates;
tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides;
20 amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates;
imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates;
organic silicates; and stibonates; and combinations thereof.

70. The method of claim 49 wherein the conversion coating bath has a concentration of
cobalt of between about 1×10^{-4} moles/liter cobalt and a concentration which is a maximum
25 solubility of the cobalt source in the solvent at a temperature of the conversion coating bath.

71. The method of claim 54 wherein the conversion coating bath has a concentration of oxidizer of between a minimum concentration wherein a majority of the cobalt is oxidized to a trivalent or tetravalent oxidation state and a maximum solubility of the oxidizer in the solvent at a temperature of the conversion coating bath.

5 72. The method of claim 62 wherein the conversion coating bath has a concentration of preparative agent between a minimum concentration wherein there is a fluoride-to-cobalt ratio of 0.05 and a maximum concentration which is a maximum solubility of the preparative agent in the solvent at a temperature of the conversion coating bath.

10 73. The method of claim 49 wherein the conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cobalt ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the solvent at a temperature of the conversion coating bath.

74. The method of claim 49 wherein the conversion coating bath has a pH of between about 0 and about 7.

15 75. The method of claim 74 wherein the conversion coating bath has a pH of between about 1 and about 6.

76. The method of claim 49 wherein the conversion coating bath has a temperature of between about 5°C and about 100°C.

20 77. The method of claim 76 wherein the conversion coating bath has a temperature of between about 5°C and about 40°C.

78. A method of applying a corrosion-inhibiting conversion coating, comprising:
providing a substrate to be coated;
contacting the substrate with a first conversion coating bath comprising a first solvent
and a cobalt source; and
5 contacting the substrate with a valence stabilizer to form a coating comprising a
cobalt/valence stabilizer complex.

79. The method of claim 78 wherein the substrate is a metal.

80. The method of claim 79 wherein the metal is selected from aluminum, zinc, magnesium,
titanium, cadmium, silver, copper, tin, lead, cobalt, zirconium, beryllium, indium, and alloys
thereof, and combinations thereof.

81. The method of claim 78 wherein the substrate is a metal with a metal coating.

82. The method of claim 81 wherein the metal coating is selected from aluminum, zinc,
magnesium, titanium, cadmium, silver, copper, tin, lead, cobalt, zirconium, beryllium, indium,
and alloys thereof, and combinations thereof.

83. The method of claim 78 wherein the first solvent comprises water.

84. The method of claim 78 wherein the cobalt source is selected from divalent cobalt,
trivalent cobalt, and tetravalent cobalt, and combinations thereof.

85. The method of claim 84 wherein the cobalt source is divalent cobalt.

86. The method of claim 78 further comprising oxidizing the cobalt source.

87. The method of claim 86 wherein the cobalt source is oxidized in the first conversion coating bath.

88. The method of claim 78 wherein the cobalt source is oxidized in the coating.

89. The method of claim 86 wherein the cobalt source is oxidized by adding an oxidizer to the first conversion coating bath.

90. The method of claim 86 wherein the cobalt source is oxidized by electrolysis.

91. The method of claim 89 wherein the oxidizer is selected from a dissolved solid, a liquid, and a gas.

92. The method of claim 89 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrites, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vanadates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, and dissolved fluorine, and combinations thereof.

93. The method of claim 78 wherein the cobalt source is selected from cobalt contained within a treated substrate, cobalt nitrate, cobalt sulfate, cobalt perchlorate, cobalt chloride, cobalt fluoride, cobalt bromide, cobalt iodide, cobalt bromate, cobalt chlorate, cobalt fluosilicate, cobalt fluotitanate, cobalt fluozirconate, cobalt fluoborate, cobalt fluoaluminate, cobalt formate, cobalt acetate, cobalt propionate, cobalt butyrate, cobalt benzoate, cobalt glycolate, cobalt lactate, cobalt tartronate, cobalt malate, cobalt tartrate, cobalt citrate, cobalt benzenesulfonate, cobalt thiocyanate, cobalt acetylacetonate, ammonium cobalt sulfate, ammonium cobalt nitrate, ammonium cobalt chloride, ammonium cobalt bromide,

hexaamminecobalt chloride, hexaamminecobalt bromide, hexaamminecobalt nitrate, pentaamminecobalt chloride, pentaamminecobalt bromide, pentaamminecobalt nitrate, lithium cobaltinitrite, sodium cobaltinitrite, tris(ethylenediamine)cobalt chloride, tris(ethylenediamine)cobalt nitrate, bipyridine complexes of trivalent cobalt, phenanthroline complexes of trivalent cobalt, and cobaltcarbonates, and combinations thereof.

94. The method of claim 78 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

95. The method of claim 78 wherein the valence stabilizer is added to the first conversion coating bath.

96. The method of claim 78 further comprising providing a second conversion coating bath comprising a second solvent and the valence stabilizer.

97. The method of claim 96 wherein the second solvent comprises water.

98. The method of claim 78 wherein the substrate is contacted with the first conversion coating bath by a process selected from immersion, spraying, fogging, wiping, and dipping.

99. The method of claim 96 wherein the substrate is contacted with the second conversion coating bath by a process selected from immersion, spraying, fogging, wiping, and dipping.

100. The method of claim 78 further comprising adding a preparative agent to the first conversion coating bath.

101. The method of claim 100 wherein the preparative agent is selected from fluorides, chlorides, bromides, acidic species, and hydroxides, and combinations thereof.

102. The method of claim 101 wherein the preparative agent is a fluoride.

103. The method of claim 102 wherein the fluoride is selected from fluorozirconates, fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates, fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates, fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates, fluoroargentates, fluorozincates, fluorohafnates, fluorovanadates, fluoroniobates, fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates, fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates, fluorocobaltates, potassium fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride, hydrofluoric acid, dissolved fluorine, and organic fluorides, and combinations thereof.

104. The method of claim 78 further comprising contacting the coating comprising the cobalt/valence stabilizer complex with a solubility control agent.

105. The method of claim 104 wherein the solubility control agent is added to the first conversion coating bath.

106. The method of claim 104 further comprising a second conversion coating bath comprising a second solvent, the valence stabilizer, and the solubility control agent.

107. The method of claim 106 wherein the second solvent is water.

108. The method of claim 104 further comprising a third conversion coating bath comprising the solubility control agent and a third solvent.

109. The method of claim 108 wherein the third solvent is water.

110. The method of claim 104 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

111. The method of claim 110 wherein the solubility control agent is the cationic solubility control agent selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Be^{+2} , Ba^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , V^{+5} , V^{+4} , V^{+3} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Cr^{+3} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ni^{+2} , Ni^{+3} , Ni^{+4} , Ru^{+2} , Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Os^{+4} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Cd^{+2} , Hg^+ , Hg^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Tl^{+3} , Tl^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Pb^{+4} , Pb^{+2} , Sb^{+3} , Sb^{+5} , As^{+3} , As^{+5} , Bi^{+3} , Bi^{+5} , organic compounds containing at least one N^+ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one arsonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one selenonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR_4^+ , where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

112. The method of claim 111 wherein the cationic solubility control agent is selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ru^{+2} , Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Sb^{+3} , Sb^{+5} , Bi^{+3} , Bi^{+5} , organic compounds containing at least one N^+ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one iodonium site, and quaternary

ammonium compounds having a formula NR_4^+ , where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

113. The method of claim 110 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; cyanides; cyanochromates; cyanonickelates;

5 cyanatochromates; cyanatonickelates; thiocyanatochromates; thiocyanatonickelates;
cyanamidochromates; cyanamidonickelates; nitritonickelates; arsonates; diarsonates;
triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites; fluoroarsenates;
chloroarsenates; selenates; selenites; fluorothallates; chlorothallates; iodoamalgam anions;
chloromercurates; bromomercurates; osmates; fluoronickelates; chromates; Reinecke's salt; and
vanadates; and combinations thereof.

114. The method of claim 113 wherein the anionic solubility control agent is selected from
fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates;
chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates;
fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates;
chlorocobaltates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides;
cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates;
thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates;
chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates;
fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates;
iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates;
cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates;
cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates;
thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferrates;
cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferrates;
nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates;
tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates;
tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates;
(thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides;
amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates;
imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates;

tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

5 115. The method of claim 78 wherein the first conversion coating bath has a concentration of cobalt of between about 1×10^{-4} moles/liter cobalt and a concentration which is a maximum solubility of the cobalt source in the first solvent at a temperature of the first conversion coating bath.

10 116. The method of claim 89 wherein the first conversion coating bath has a concentration of oxidizer of between a minimum concentration wherein a majority of the cobalt is oxidized to a trivalent or tetravalent oxidation state and a maximum solubility of the oxidizer in the first solvent at a temperature of the first conversion coating bath.

15 117. The method of claim 102 wherein the first conversion coating bath has a concentration of preparative agent between a minimum concentration wherein there is a fluoride-to-cobalt ratio of 0.05 and a maximum concentration which is a maximum solubility of the preparative agent in the first solvent at a temperature of the first conversion coating bath.

20 118. The method of claim 78 wherein the first conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cobalt ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the first solvent at a temperature of the first conversion coating bath.

119. The method of claim 78 wherein the first conversion coating bath has a pH of between about 0 and about 7.

120. The method of claim 119 wherein the first conversion coating bath has a pH of between about 1 and about 6.

121. The method of claim 78 wherein the first conversion coating bath has a temperature of between about 5°C and about 100°C.

5 122. The method of claim 121 wherein the first conversion coating bath has a temperature of between about 5°C and about 40°C.

123. A corrosion-inhibiting conversion coating bath comprising a solvent, a cobalt source, and a valence stabilizer combined to form a cobalt/valence stabilizer complex.

124. The conversion coating bath of claim 123 wherein the solvent is water.

10 125. The conversion coating bath of claim 123 further comprising an oxidizer.

126. The conversion coating bath of claim 125 wherein the oxidizer is selected from a dissolved solid, a liquid, and a gas.

15 127. The conversion coating bath of claim 126 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrates, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vanadates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, and dissolved fluorine, and combinations thereof.

128. The conversion coating bath of claim 123 wherein the cobalt source is selected from cobalt contained within a treated substrate, cobalt nitrate, cobalt sulfate, cobalt perchlorate, cobalt chloride, cobalt fluoride, cobalt bromide, cobalt iodide, cobalt bromate, cobalt chlorate, cobalt fluosilicate, cobalt fluotitanate, cobalt fluozirconate, cobalt fluoborate, cobalt fluoaluminate, cobalt formate, cobalt acetate, cobalt propionate, cobalt butyrate, cobalt benzoate, cobalt glycolate, cobalt lactate, cobalt tartronate, cobalt malate, cobalt tartrate, cobalt citrate, cobalt benzenesulfonate, cobalt thiocyanate, cobalt acetylacetonate, ammonium cobalt sulfate, ammonium cobalt nitrate, ammonium cobalt chloride, ammonium cobalt bromide, hexaamminecobalt chloride, hexaamminecobalt bromide, hexaamminecobalt nitrate, pentaamminecobalt chloride, pentaamminecobalt bromide, pentaamminecobalt nitrate, lithium cobaltinitrite, sodium cobaltinitrite, tris(ethylenediamine)cobalt chloride, tris(ethylenediamine)cobalt nitrate, bipyridine complexes of trivalent cobalt, phenanthroline complexes of trivalent cobalt, and cobalt carbonates, and combinations thereof.

129. The conversion coating bath of claim 123 further comprising a preparative agent.

130. The conversion coating bath of claim 129 wherein the preparative agent is selected from fluorides, chlorides, bromides, and hydroxides, and combinations thereof.

131. The conversion coating bath of claim 130 wherein the preparative agent is a fluoride.

132. The conversion coating bath of claim 131 wherein the fluoride is selected from fluoro zirconates, fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates, fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates, fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates, fluoroargentates, fluorozincates, fluorohafnates, fluorovanadates, fluoroniobates, fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates, fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates,

fluorocobaltates, potassium fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride, hydrofluoric acid, dissolved fluorine, and organic fluorides, and combinations thereof.

5 133. The conversion coating bath of claim 123 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

134. The conversion coating bath of claim 123 further comprising a solubility control agent.

135. The conversion coating bath of claim 134 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

10 136. The conversion coating bath of claim 135 wherein the solubility control agent is the cationic solubility control agent selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Be^{+2} , Ba^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , V^{+5} , V^{+4} , V^{+3} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Cr^{+3} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ni^{+2} , Ni^{+3} , Ni^{+4} , Ru^{+2} ,
15 Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Os^{+4} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Cd^{+2} , Hg^+ , Hg^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Tl^{+3} , Tl^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Pb^{+4} , Pb^{+2} , Sb^{+3} , Sb^{+5} , As^{+3} , As^{+5} , Bi^{+3} , Bi^{+5} , organic compounds containing at least one N^+ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one arsonium site, organic compounds containing at least one stibonium site, organic
20 compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one selenonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR_4^+ , where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

137. The conversion coating bath of claim 136 wherein the cationic solubility control agent is selected from H^+ , Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Sr^{+2} , Y^{+3} , La^{+3} , Ce^{+3} , Ce^{+4} , Nd^{+3} , Pr^{+3} , Sc^{+3} , Sm^{+3} , Eu^{+3} , Eu^{+2} , Gd^{+3} , Tb^{+3} , Dy^{+3} , Ho^{+3} , Er^{+3} , Tm^{+3} , Yb^{+3} , Lu^{+3} , Ti^{+4} , Zr^{+4} , Ti^{+3} , Hf^{+4} , Nb^{+5} , Ta^{+5} , Nb^{+4} , Ta^{+4} , Mo^{+6} , W^{+6} , Mo^{+5} , W^{+5} , Mo^{+4} , W^{+4} , Mn^{+2} , Mn^{+3} , Mn^{+4} , Fe^{+2} , Fe^{+3} , Co^{+2} , Co^{+3} , Ru^{+2} , Ru^{+3} , Ru^{+4} , Rh^{+3} , Ir^{+3} , Rh^{+2} , Ir^{+2} , Pd^{+4} , Pt^{+4} , Pd^{+2} , Pt^{+2} , Cu^+ , Cu^{+2} , Cu^{+3} , Ag^+ , Ag^{+2} , Ag^{+3} , Au^+ , Au^{+2} , Au^{+3} , Zn^{+2} , Al^{+3} , Ga^{+3} , Ga^+ , In^{+3} , In^+ , Ge^{+4} , Ge^{+2} , Sn^{+4} , Sn^{+2} , Sb^{+3} , Sb^{+5} , Bi^{+3} , Bi^{+5} , organic compounds containing at least one N^+ site, organic compounds containing at least one phosphonium site, organic compounds containing at least one stibonium site, organic compounds containing at least one oxonium site, organic compounds containing at least one sulfonium site, organic compounds containing at least one iodonium site, and quaternary ammonium compounds having a formula NR_4^+ , where R is an alkyl, aromatic, or acyclic organic constituent, and combinations thereof.

138. The conversion coating bath of claim 135 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates;

nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates;
tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates;
tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates;
tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides;
5 tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates;
triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates;
(thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides;
di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates;
triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates;
10 di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates;
cyanonickelates; cyanatochromates; cyanatonickelates; thiocyanatochromates;
thiocyanatonickelates; cyanamidochromates; cyanamidonickelates; nitritonickelates; arsonates;
diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites;
fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates;
15 iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronickelates;
chromates; Reinecke's salt; and vanadates; and combinations thereof.

139. The conversion coating bath of claim 138 wherein the anionic solubility control agent is
selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates;
fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates;
20 permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates;
fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates;
fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates;
nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites;
thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates;
25 fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites;
dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides;
bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides;

5 cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanato ferrates;
cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanato ferrates;
thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides;
cyanamido ferrates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates;
10 nitrito ferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates;
tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates;
tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates;
tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides;
tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates;
15 triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates;
(thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides;
di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates;
triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates;
di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

15 140. The conversion coating bath of claim 123 wherein the conversion coating bath has a
concentration of cobalt of between about 1×10^{-4} moles/liter cobalt and a concentration which
is a maximum solubility of the cobalt source in the solvent at a temperature of the conversion
coating bath.

20 141. The conversion coating bath of claim 125 wherein the conversion coating bath has a
concentration of oxidizer of between a minimum concentration wherein a majority of the cobalt
is oxidized to a trivalent or tetravalent oxidation state and a maximum solubility of the oxidizer
in the solvent at a temperature of the conversion coating bath.

25 142. The conversion coating bath of claim 131 wherein the conversion coating bath has a
concentration of preparative agent between a minimum concentration wherein there is a
fluoride-to-cobalt ratio of 0.05 and a maximum concentration which is a maximum solubility of

the preparative agent in the solvent at a temperature of the conversion coating bath.

143. The conversion coating bath of claim 123 wherein the conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cobalt ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the solvent at a temperature of the conversion coating bath.

144. The conversion coating bath of claim 123 wherein the conversion coating bath has a pH of between about 0 and about 7.

145. The conversion coating bath of claim 144 wherein the conversion coating bath has a pH of between about 1 and about 6.

146. The conversion coating bath of claim 123 wherein the conversion coating bath has a temperature of between about 5°C and about 100°C.

147. The conversion coating bath of claim 146 wherein the conversion coating bath has a temperature of between about 5°C and about 40°C.

148. A corrosion-inhibiting conversion coating comprising cobalt, wherein the cobalt is trivalent cobalt, or tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

149. A method of making a corrosion-inhibiting conversion coating bath comprising:
providing a solvent;
providing a cobalt source;

providing a valence stabilizer; and

combining the cobalt source and the valence stabilizer to form a cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

- 5 150. A method of applying a corrosion-inhibiting conversion coating, comprising:
providing a substrate to be coated;
contacting the substrate with a first conversion coating bath comprising a first solvent
and a cobalt source; and
contacting the substrate with a valence stabilizer to form a coating comprising a
10 cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly
soluble in water at about 25°C and about 760 Torr.
- 15 151. A corrosion-inhibiting conversion coating bath comprising a solvent, a cobalt source,
and a valence stabilizer combined to form a cobalt/valence stabilizer complex, wherein the
cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760
Torr.